LPR Surface Sediment COPC Mapping Approach

Presentation to EPA Region 2
LPR CPG Modeling Team
9/26/2013

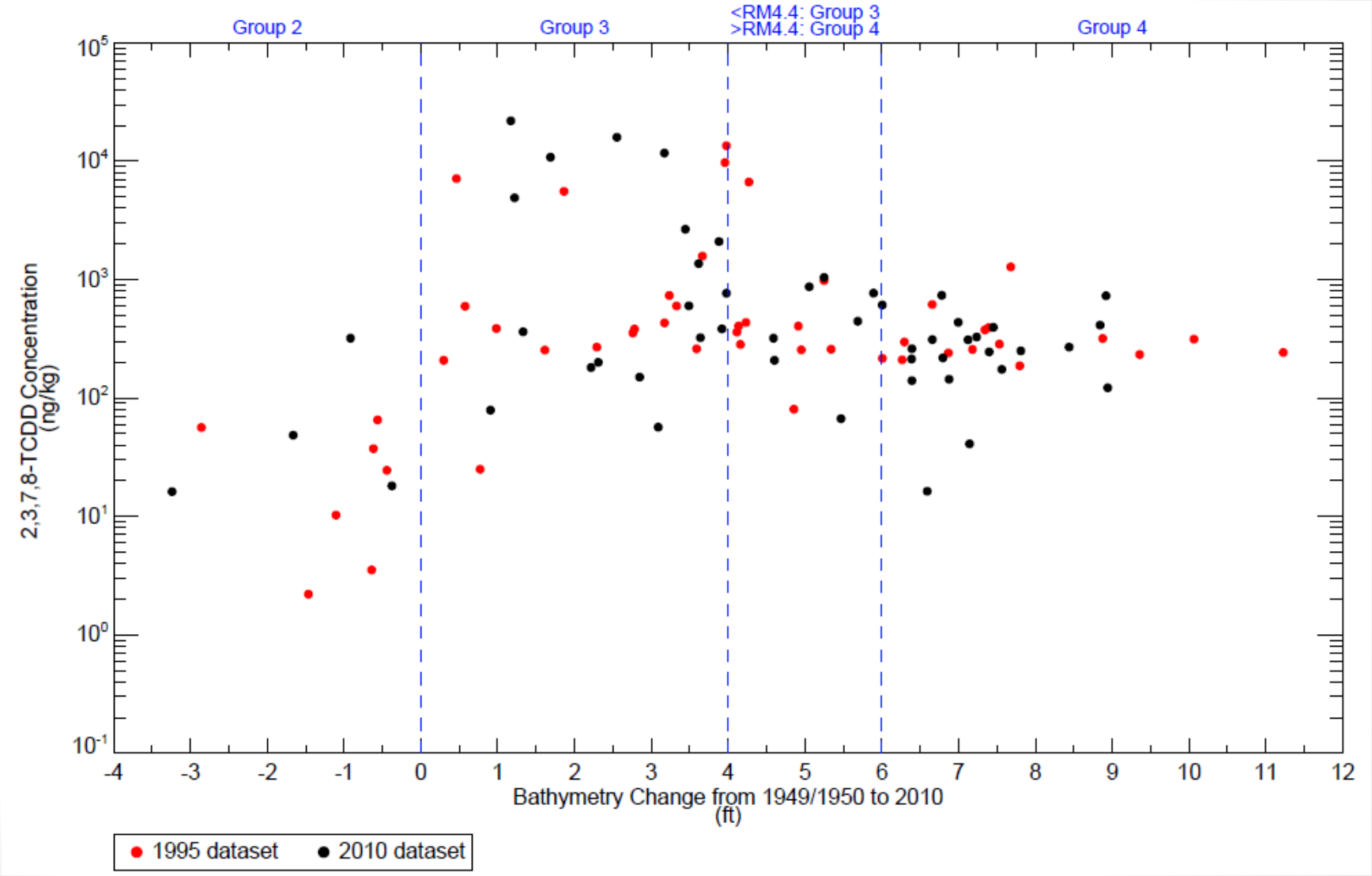
620507

Initial Surface Mapping – RM 1-7

- Shoals (Group 1)

- Former navigation channel
  - Partition based on 1949 to 2010 deposition rates
    - No historical deposition (Group 2)
    - Little to moderate historical deposition (Group 3)
    - High historical deposition (Group 4)

Motivation for Partitioning the Former Navigational Channel



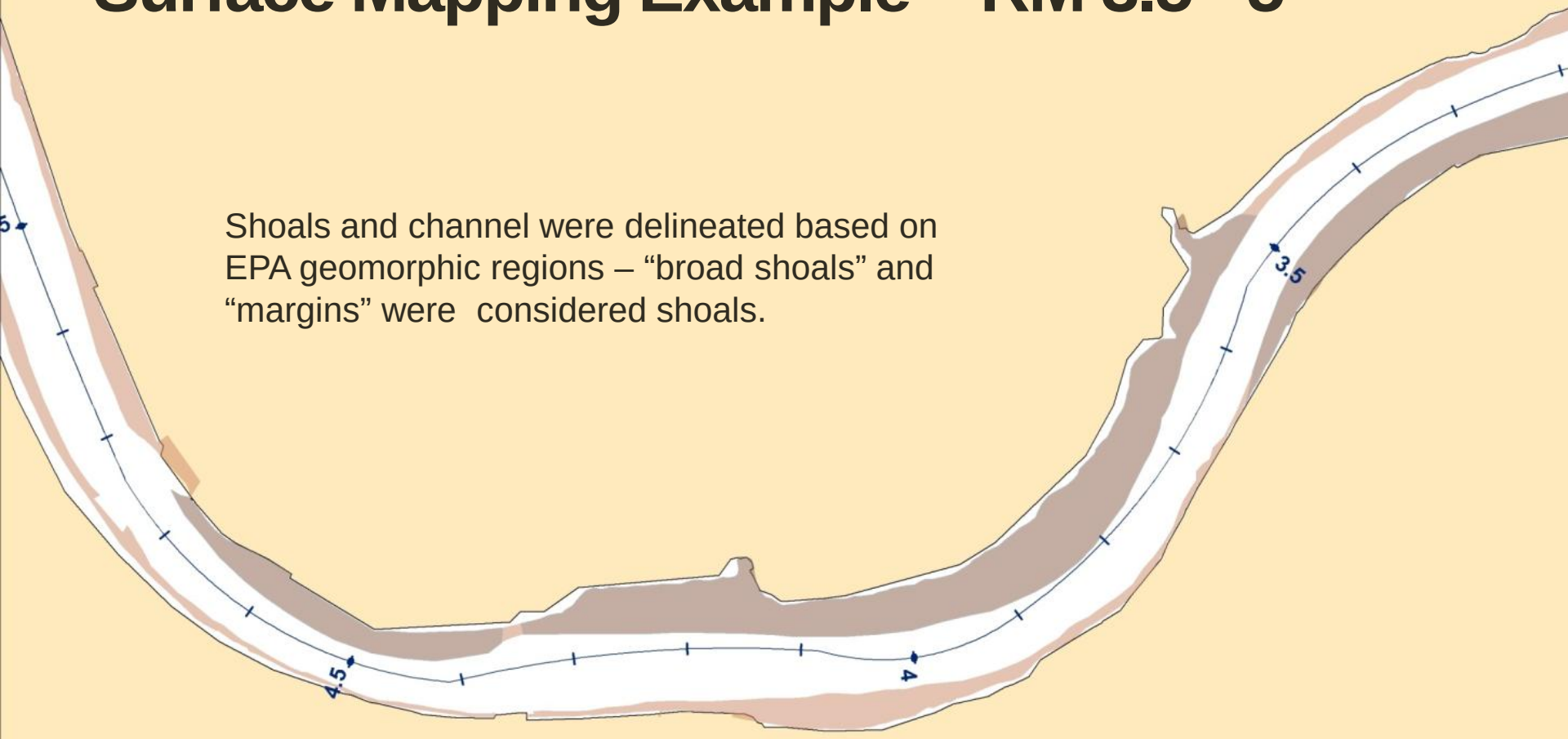
Interpolation Approaches

- Shoals (Group 1)
  - Use Thiessen polygons

- Former navigation channel
  - No historical deposition (Group 2)
    - low concentrations → use averages
  - Little to moderate historical deposition (Group 3)
    - highly variable concentrations → use Thiessen polygons
  - High historical deposition (Group 4)
    - average concentrations → use averages

Surface Mapping Example – RM 3.5 - 5

Shoals and channel were delineated based on EPA geomorphic regions – “broad shoals” and “margins” were considered shoals.



EPA Geomorphic Regions

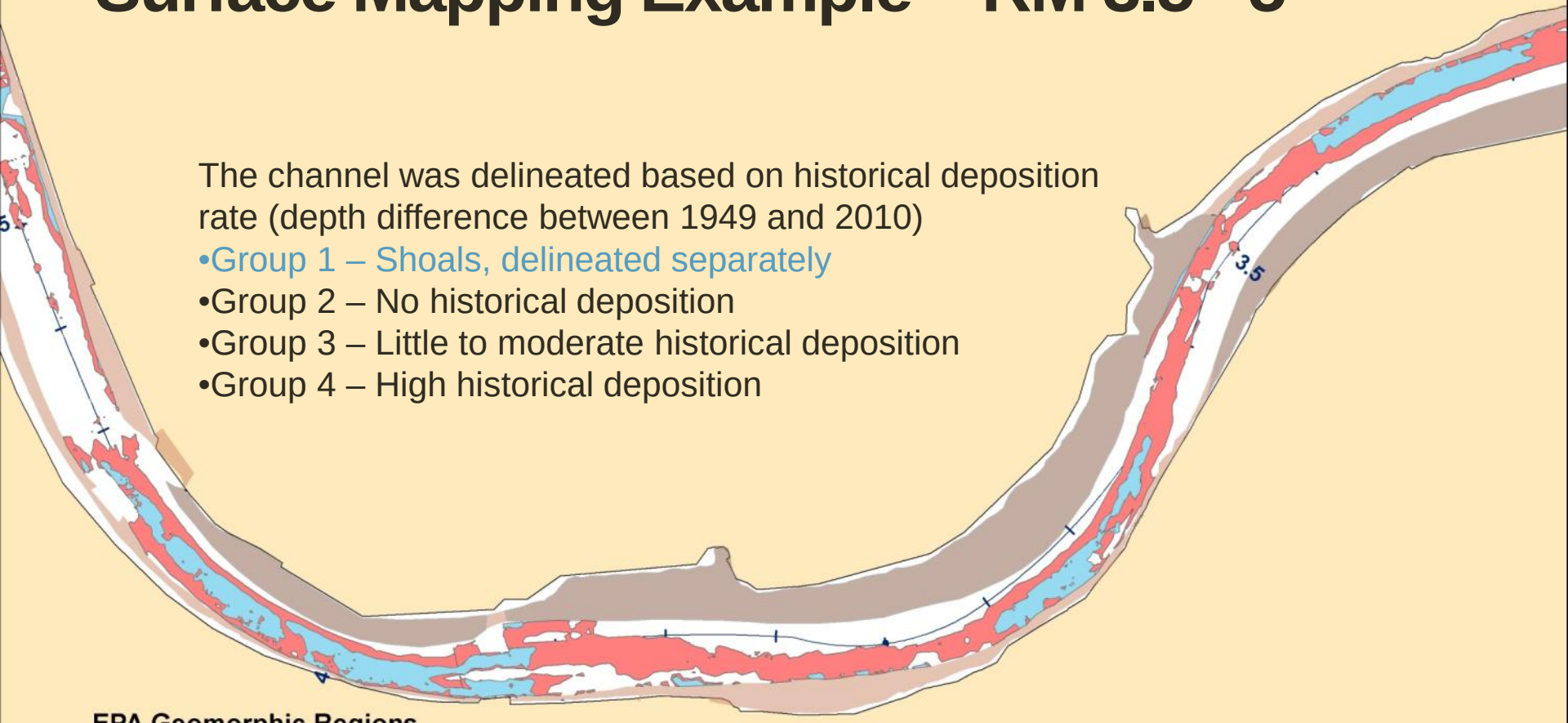
- Broad Shoal
- Margins

0 0.25 0.5 Miles

Surface Mapping Example – RM 3.5 - 5

The channel was delineated based on historical deposition rate (depth difference between 1949 and 2010)

- Group 1 – Shoals, delineated separately
- Group 2 – No historical deposition
- Group 3 – Little to moderate historical deposition
- Group 4 – High historical deposition



EPA Geomorphic Regions

Broad Shoal

Margins

Groupings

Group 2 - No historical deposition

Group 3 - Little to moderate historical deposition

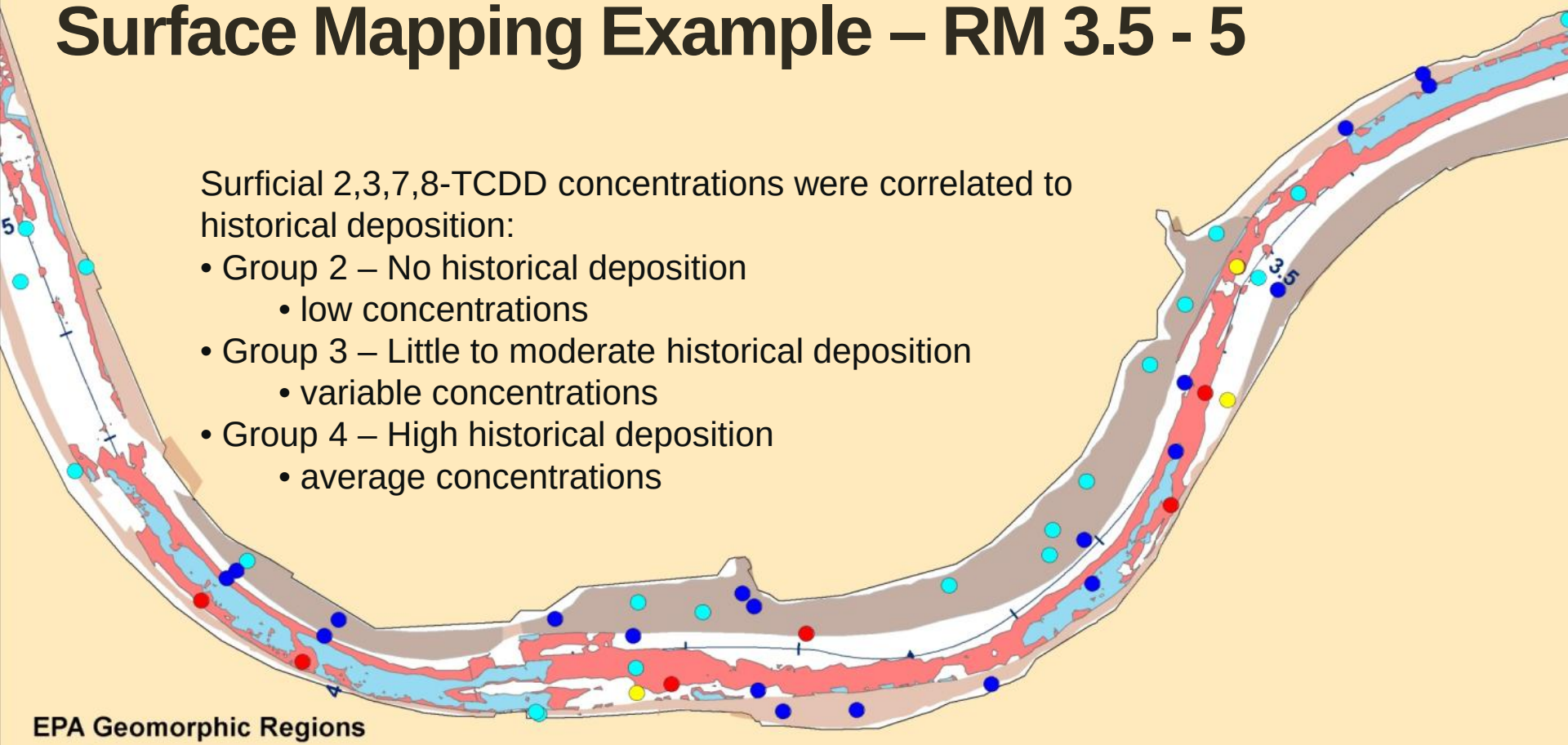
Group 4 – High historical deposition

0 0.25 0.5 Miles

Surface Mapping Example – RM 3.5 - 5

Surficial 2,3,7,8-TCDD concentrations were correlated to historical deposition:

- Group 2 – No historical deposition
  - low concentrations
- Group 3 – Little to moderate historical deposition
  - variable concentrations
- Group 4 – High historical deposition
  - average concentrations



EPA Geomorphic Regions

Broad Shoal

Margins

Groupings

Group 2 - No historical deposition

Group 3 - Little to moderate historical deposition

Group 4 – High historical deposition

2,3,7,8-TCDD (ppt)

<200

200-500

500-1000

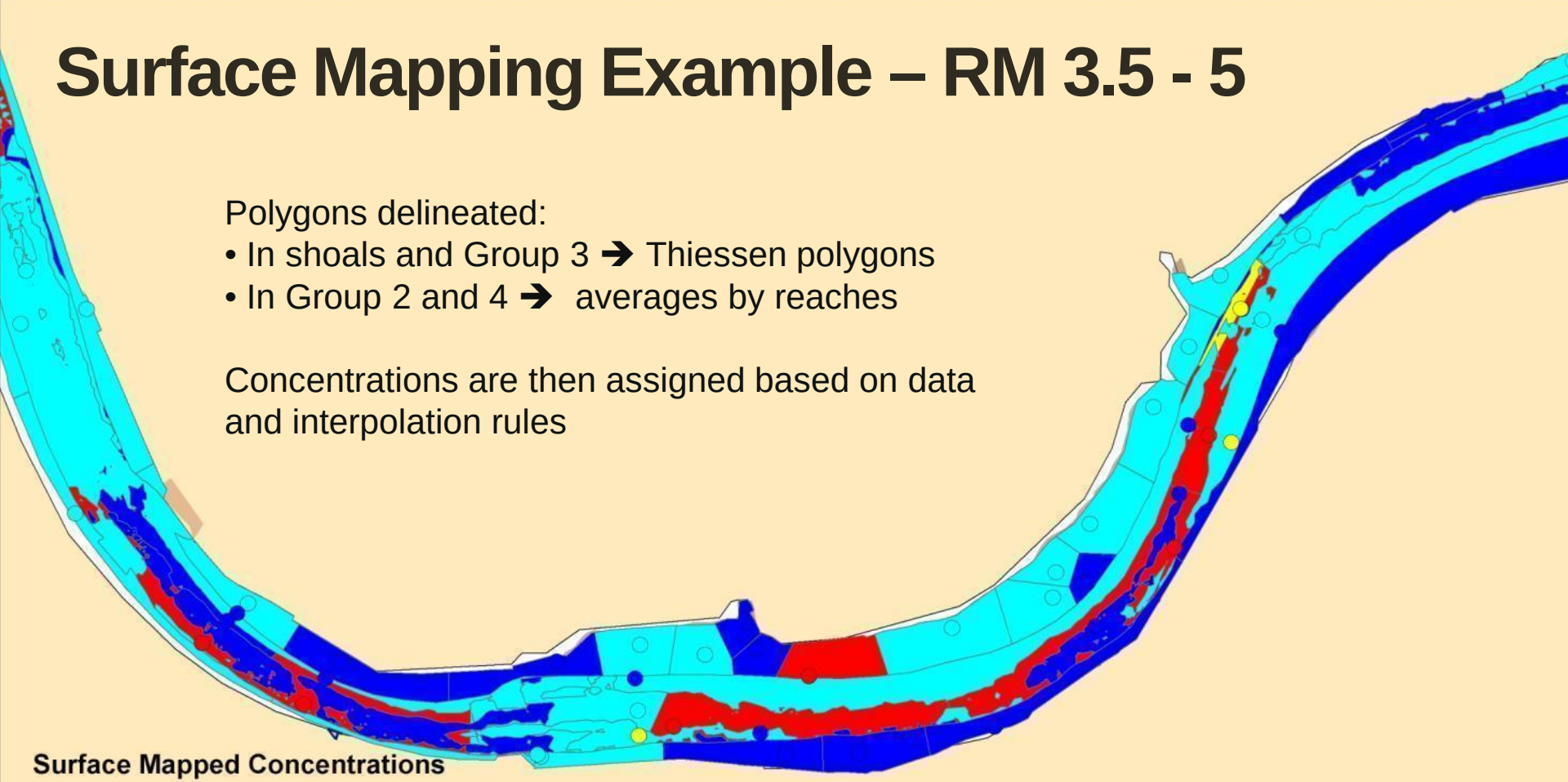
>1000

0 0.25 0.5 Miles

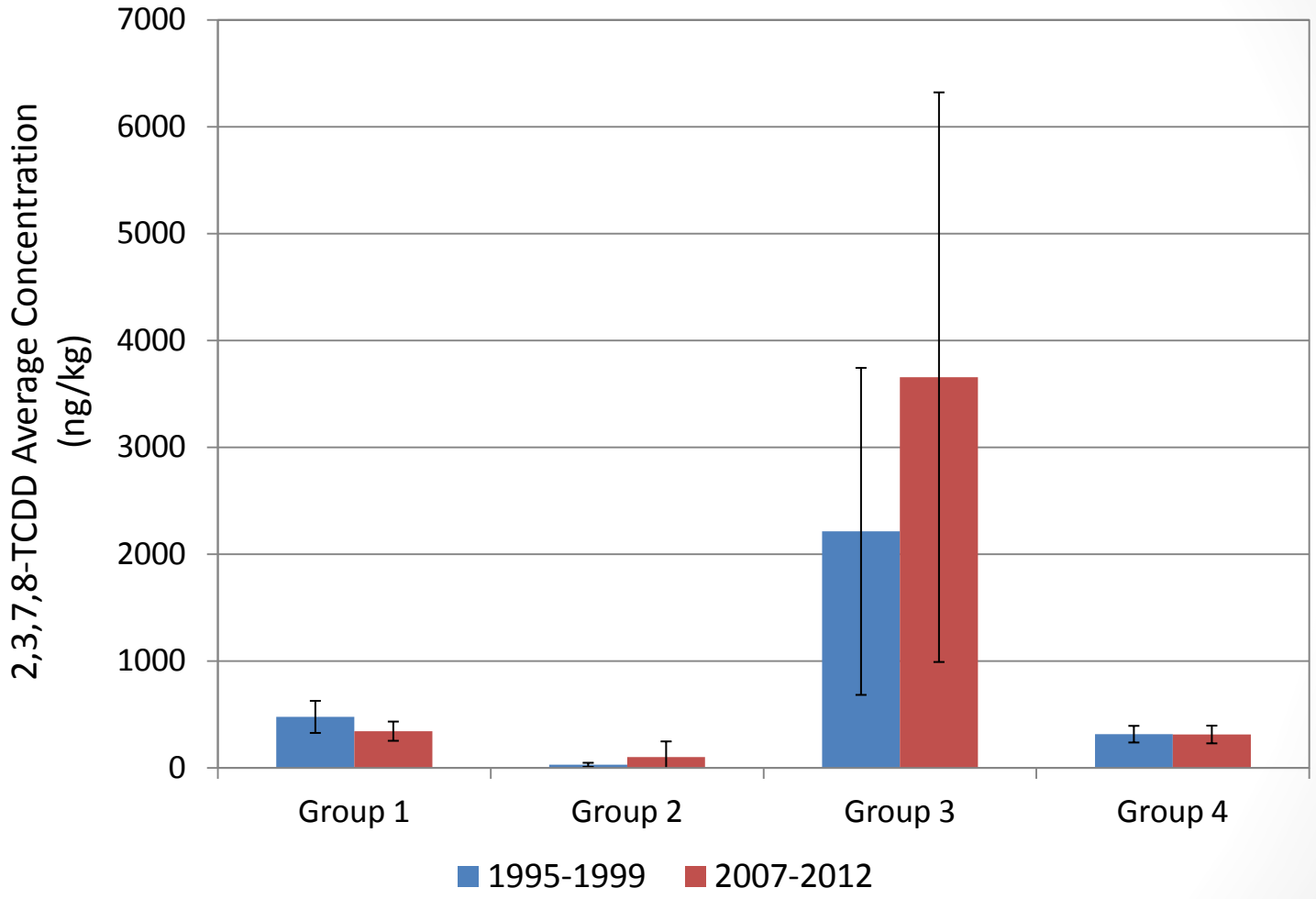
Surface Mapping Example – RM 3.5 - 5

Polygons delineated:
- In shoals and Group 3 ➔ Thiessen polygons
- In Group 2 and 4 ➔ averages by reaches

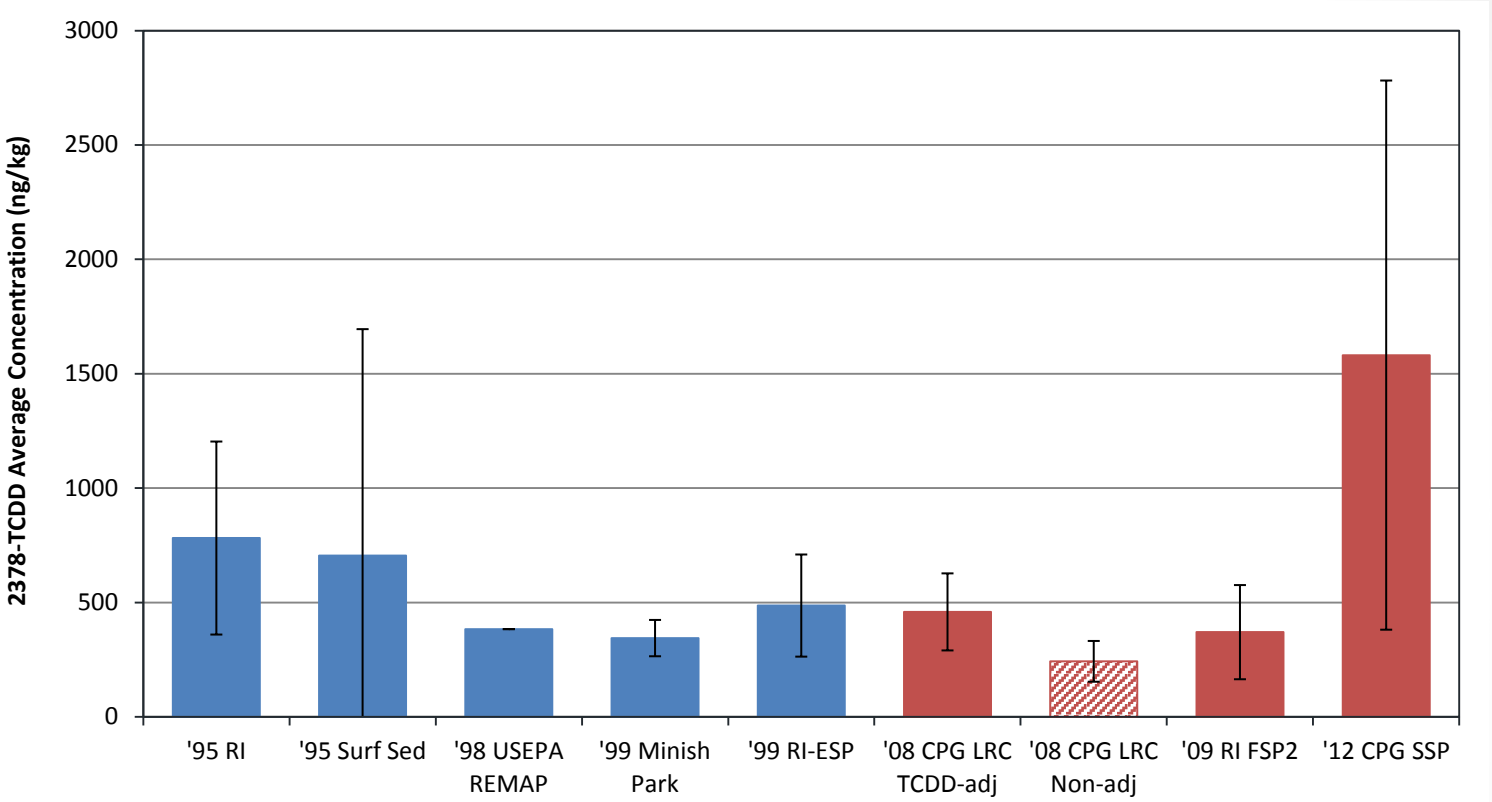
Concentrations are then assigned based on data and interpolation rules



Arithmetic Averages by Initial Groupings

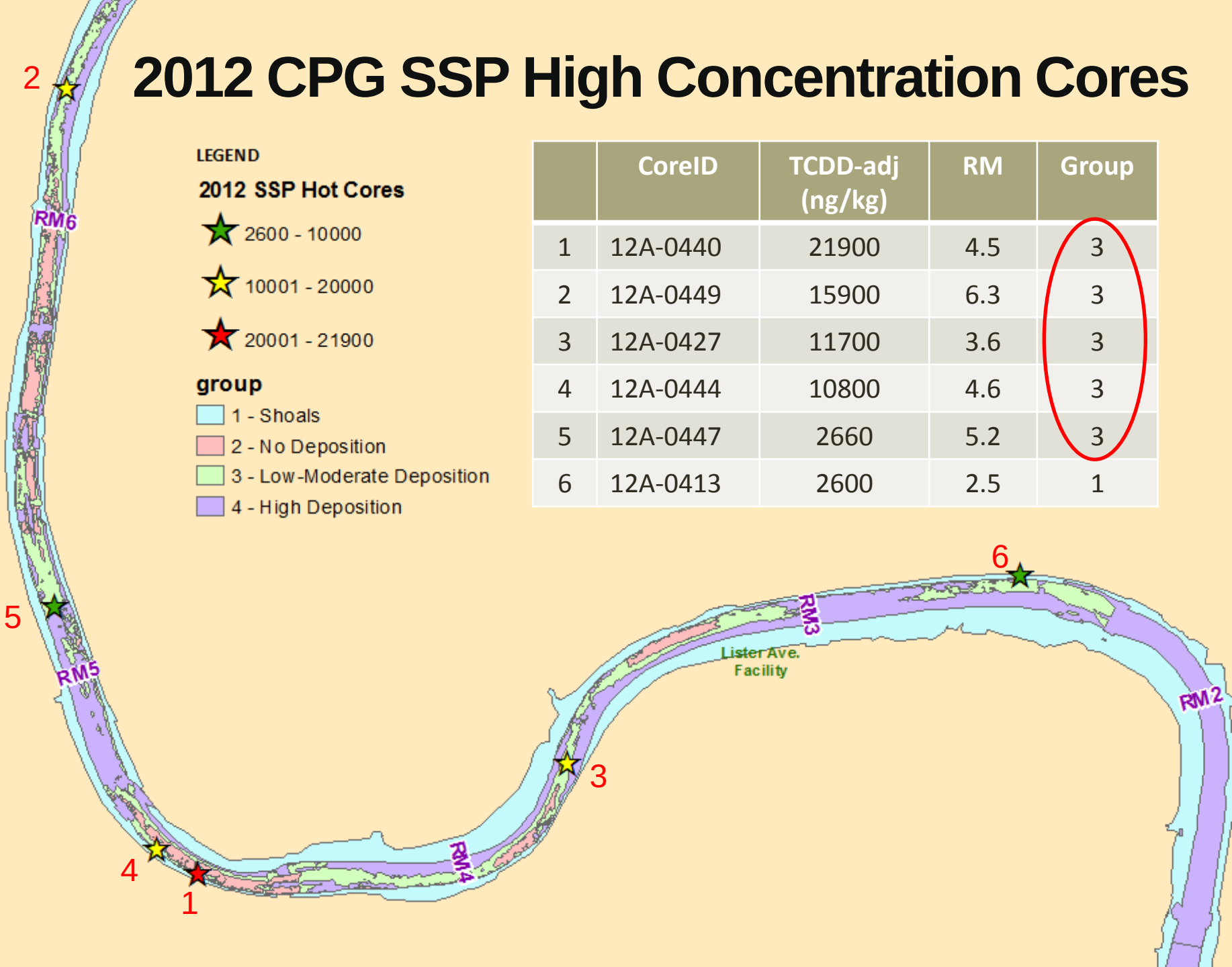


Arithmetic Averages by Study



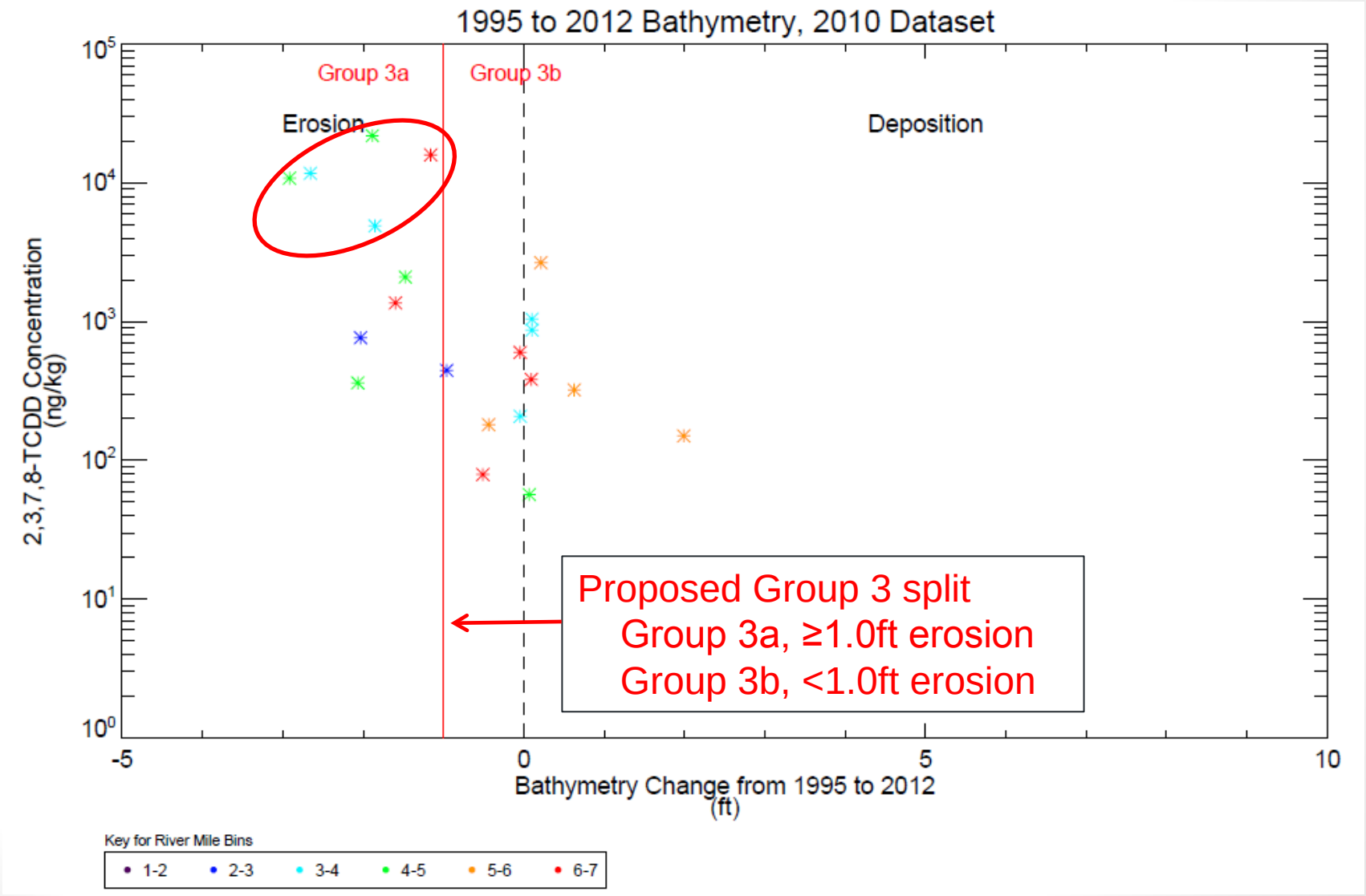
- 2012 CPG SSP cores driving high concentrations in 2008-2012 dataset
- Next step: Explore cores to see what is driving high concentrations
  - Grouping
  - Bathymetry changes

2012 CPG SSP High Concentration Cores



	CoreID	TCDD-adj (ng/kg)	RM	Group
1	12A-0440	21900	4.5	3
2	12A-0449	15900	6.3	3
3	12A-0427	11700	3.6	3
4	12A-0444	10800	4.6	3
5	12A-0447	2660	5.2	3
6	12A-0413	2600	2.5	1

2378-TCDD Concentration vs 1995 to 2012 Bathymetry Change



Revision of Initial Groups

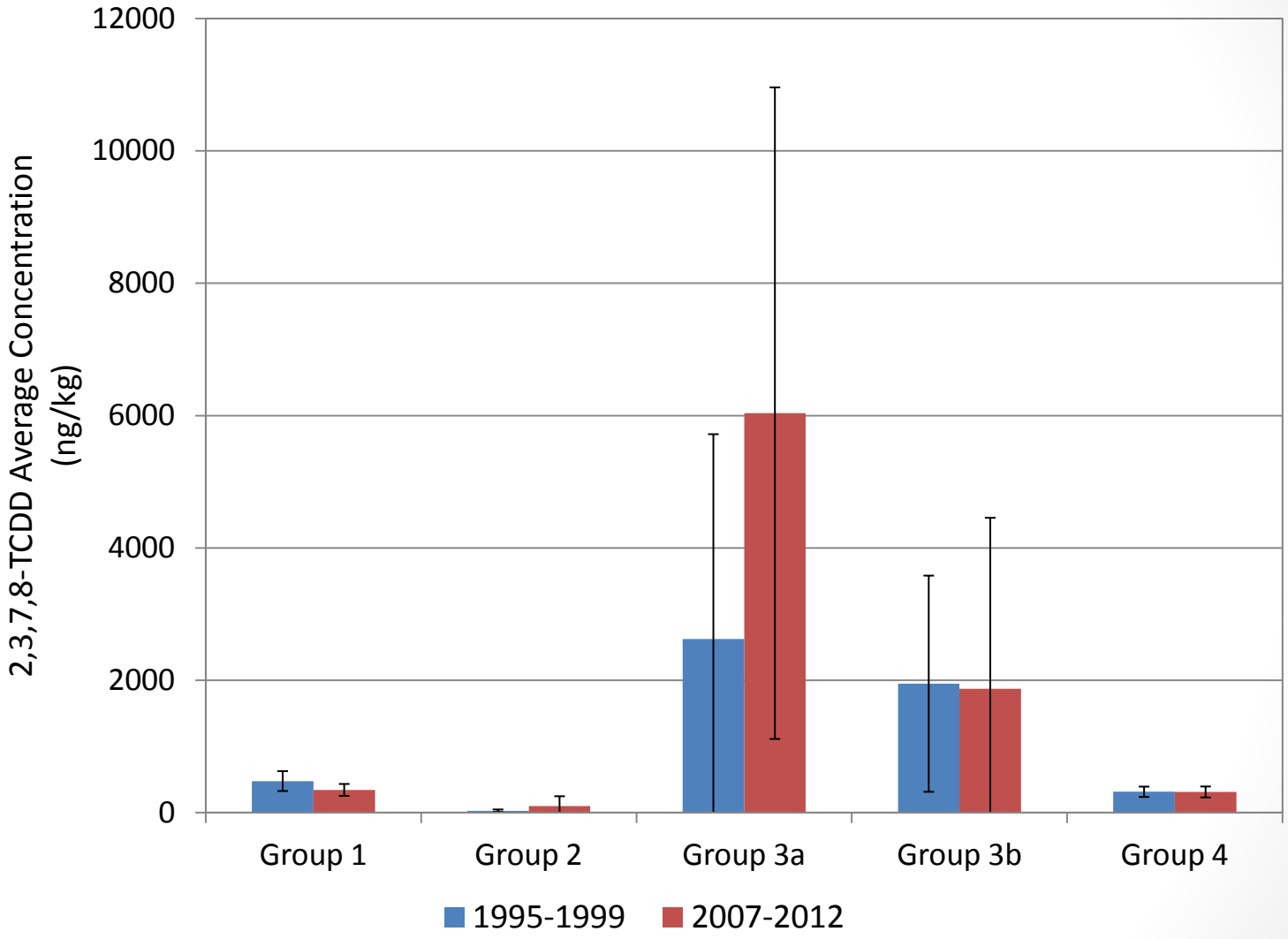
Initial Groups

Groups	Depositional Characteristics	Concentration Characteristics
Group 1	Shoals	Variable concentrations
Group 2	No historical deposition	Low concentrations
Group 3	Little to moderate historical deposition	Highly variable concentrations
Group 4	High historical deposition	Average concentrations

Refined Groups

Groups	Deposition Characteristics	Concentration Characteristics
Group 1	Shoals	Variable concentrations
Group 2	No historical deposition	Low concentrations
Group 3a	Little to moderate historical deposition, ≥1ft erosion 1995 to 2012	Highly variable concentrations, High 2012 SSP cores
Group 3b	Little to moderate historical deposition, <1ft erosion 1995 to 2012	Highly variable concentrations
Group 4	High historical deposition	Average concentrations

Arithmetic Averages by Revised Groupings



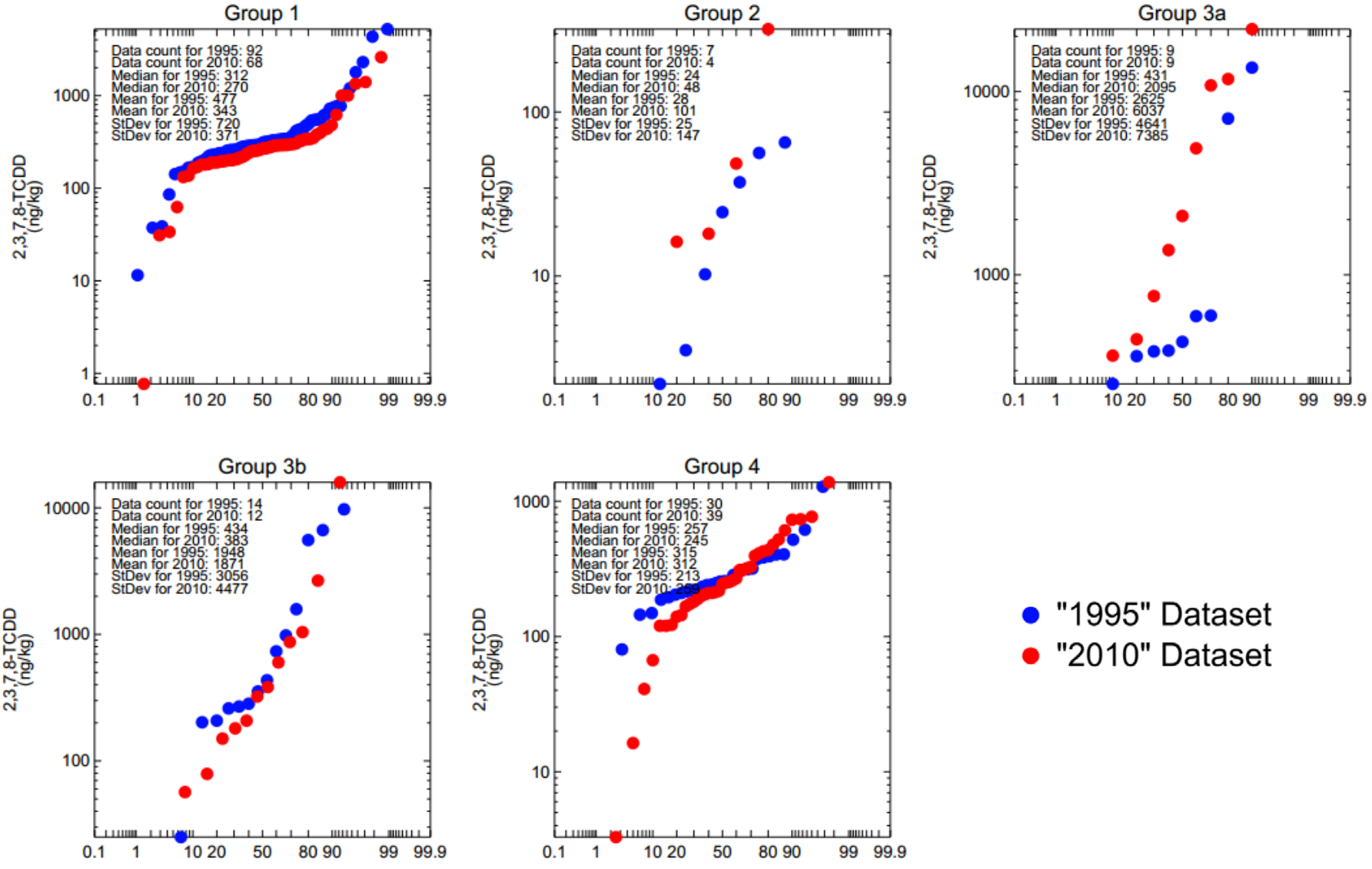
EPA-Requested Information

Areas of Groups

Groups	Deposition Characteristics	Area RM 1 to RM 7 (acres)	Area RM 0 to RM 7.5 (acres)
Group 1	Shoals	155	369
Group 2	No historical deposition	21	21
Group 3a	Little to moderate historical deposition, ≥1ft erosion 1995 to 2012	14	14
Group 3b	Little to moderate historical deposition, <1ft erosion 1995 to 2012	41	41
Group 4	High historical deposition	137	208

EPA-Requested Information

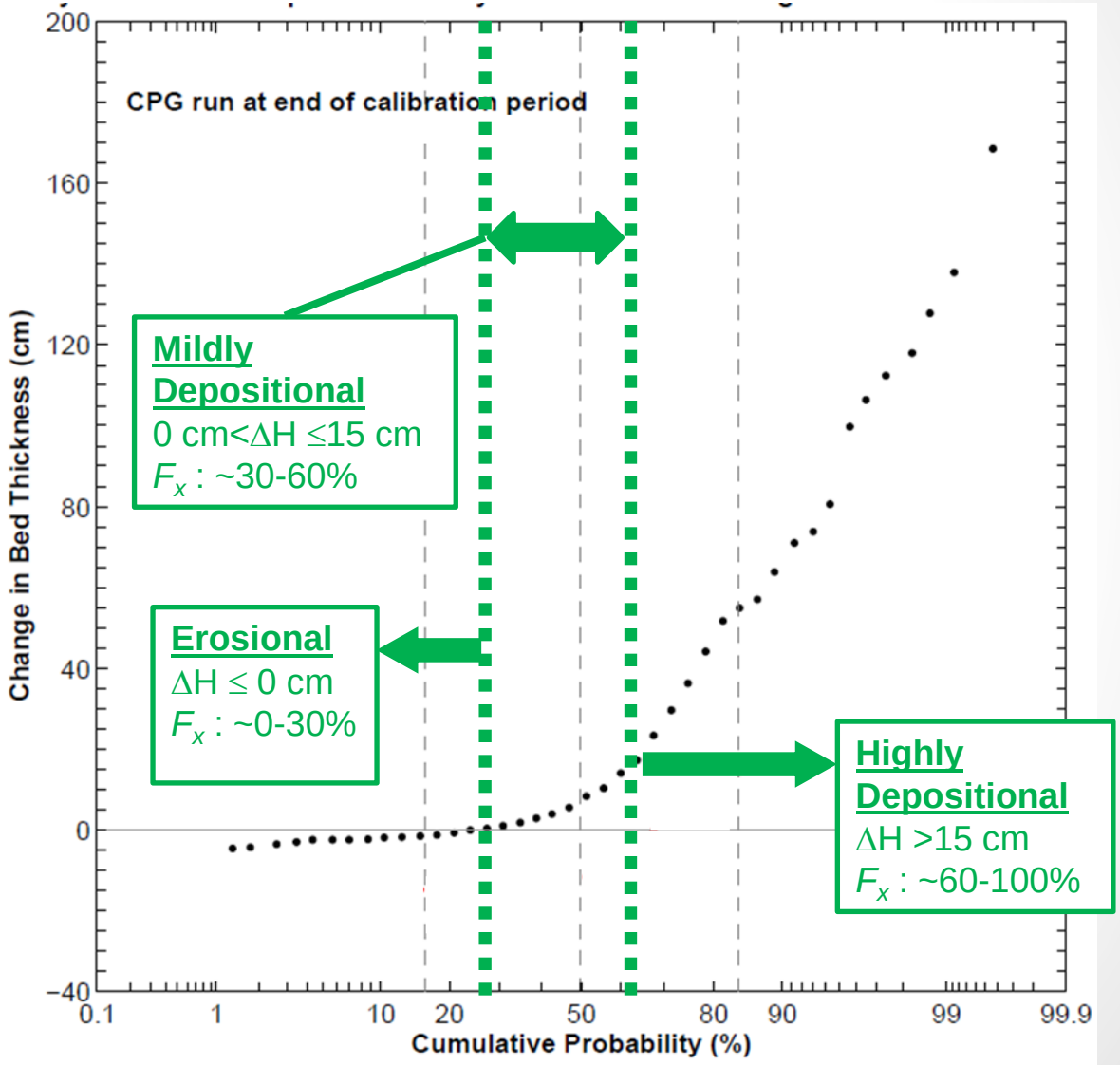
Data Counts & Distributions (log scale)



For Trend Analysis, Divide River into Depositional Regimes Defined by Predicted Bed Elevation Change, 1995 – 2010

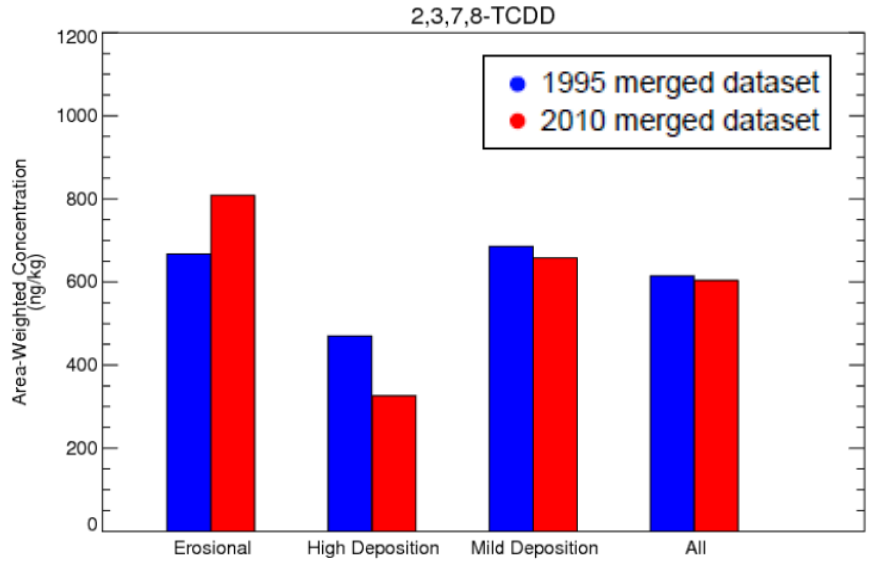
Model results for RM0 to RM8 only

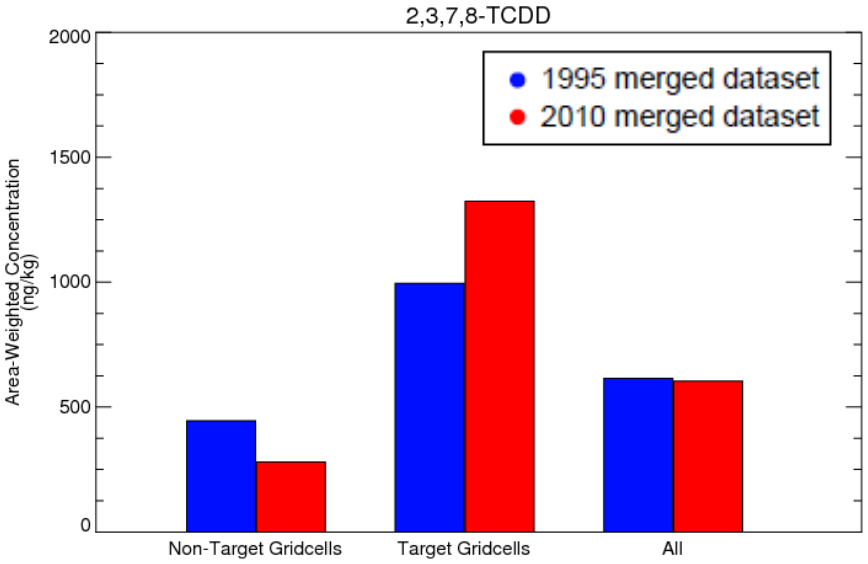
(CPG model results as of February 2013)



Mapping Results

Area-Weighted Average Trends (RM 1 to RM 7)





Surface map averaged by model calibration regime (based on ST results as of Feb 2013)

Averaged by 500 ppt target areas (on model grid)

Interpolation Approach above RM 7.5

- Interpolate using Thiessen polygons
  - Separately for silt deposits (based on side scan sonar delineations)
  - For remaining area, separately for
    - Right shoal
    - Left shoal
    - Channel
- Applicable to the 2010 dataset only
  - Due to data coverage, the 1995 surface uses 2010 data outside of approximately RM 1 to RM 7

Mapping Results

Targeted Remedy Evaluation, RM 0-14

Averaging Zone within RM 0-14	Mean 2378-TCDD Concentration (ng/kg)	Mean Tetra-CB Concentration* (ug/kg)
Target areas only (500 ppt ~ 130 acres)	4,920	2,065
Non-target areas only	200	310
All areas, including target areas	880	563
All areas, remediating target areas	172	265
Percent reduction in mean concentration	80%	53%

*Preliminary, subject to revision

Exploration of Alternative Interpolation Approaches

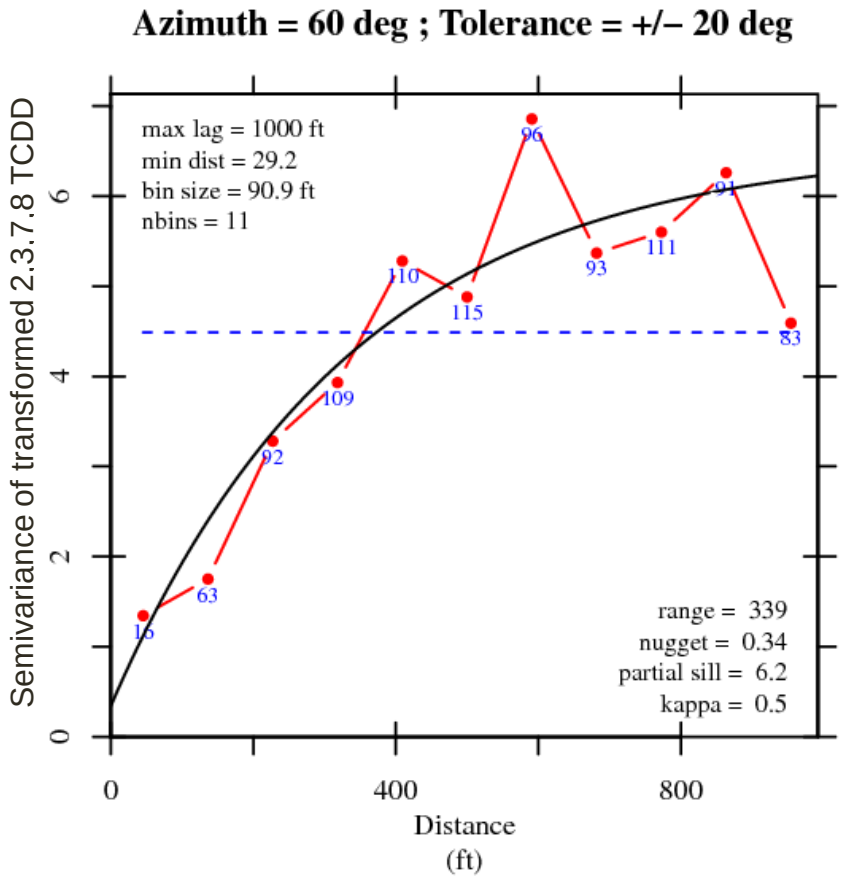
- Motivated by EPA comments on the use of Thiessen polygons and suggestion that CPG explore geostatistical interpolation techniques
- Also based on CPG concern about extrapolation distances in areas with sparse data

Interpolation Alternatives Examined

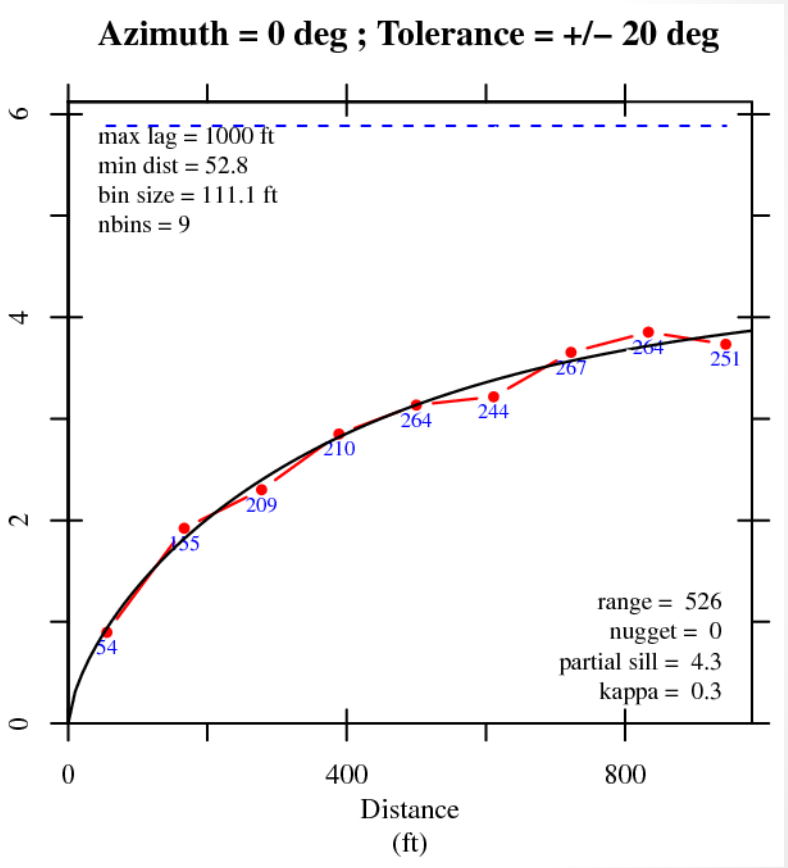
- Restricting Thiessen polygon extent to distance of spatial correlation (based on variograms)
- Inverse Distance Weighting (IDW)
- Kriging

LPR Variograms for 2,3,7,8-TCDD

RM 10.9 deposit



Straightened river, all data

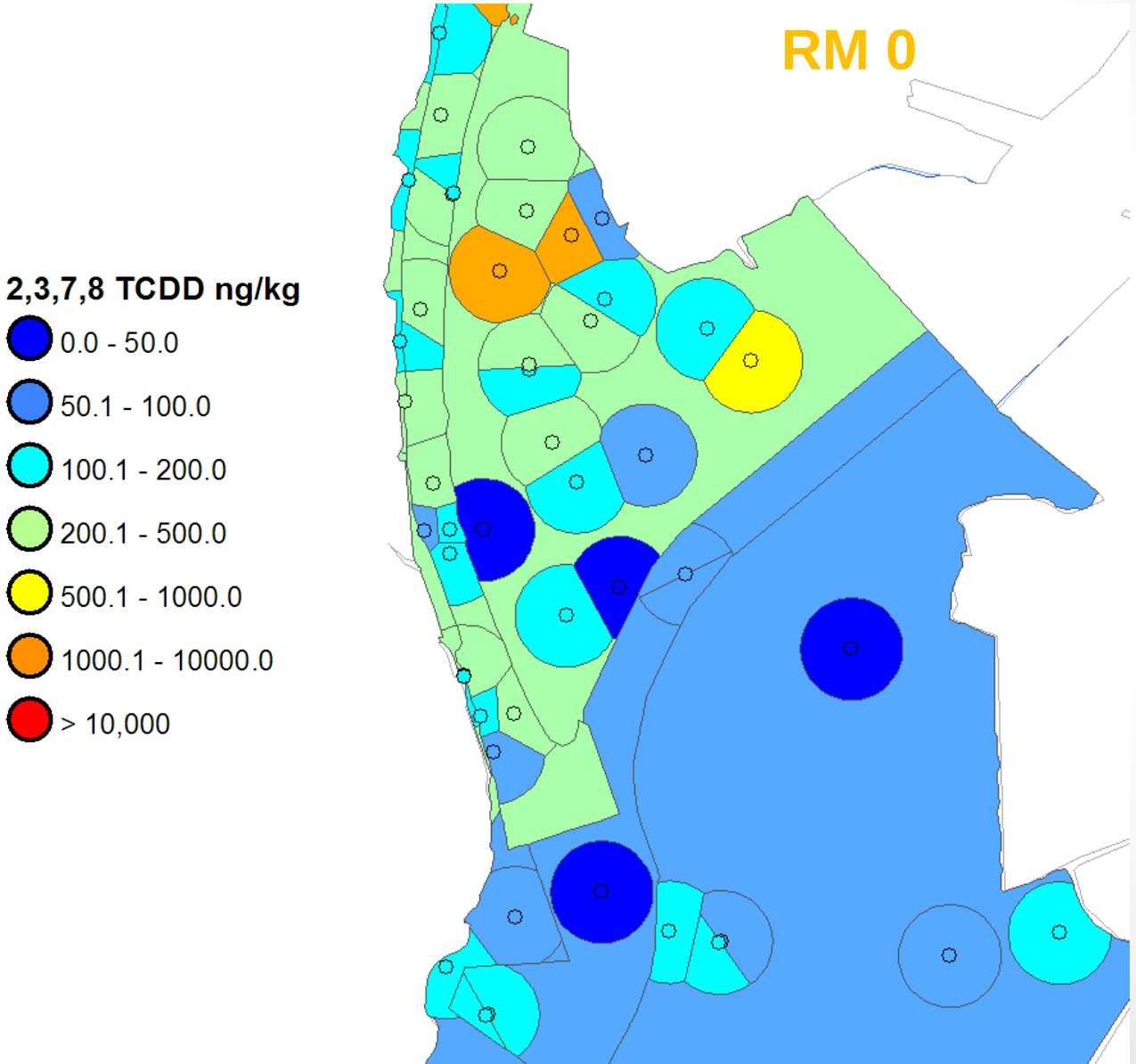


Mapping Alternative #1
Restricted Thiessen Polygons

- Restricted Thiessen polygon maximum radius to 400 feet, based on 2378-TCDD variogram
- For areas more than 400 feet from any measurement, apply a group mean concentration
  - Necessitated dividing groups into longitudinal RM bins to specify more realistic local means
- Result: an unrealistic surface that is of no use in crafting targeted remedies

Mapping Alternative #1

Restricted Thiessen Polygons



Mapping Alternative #2
Inverse Distance Weighting (IDW)

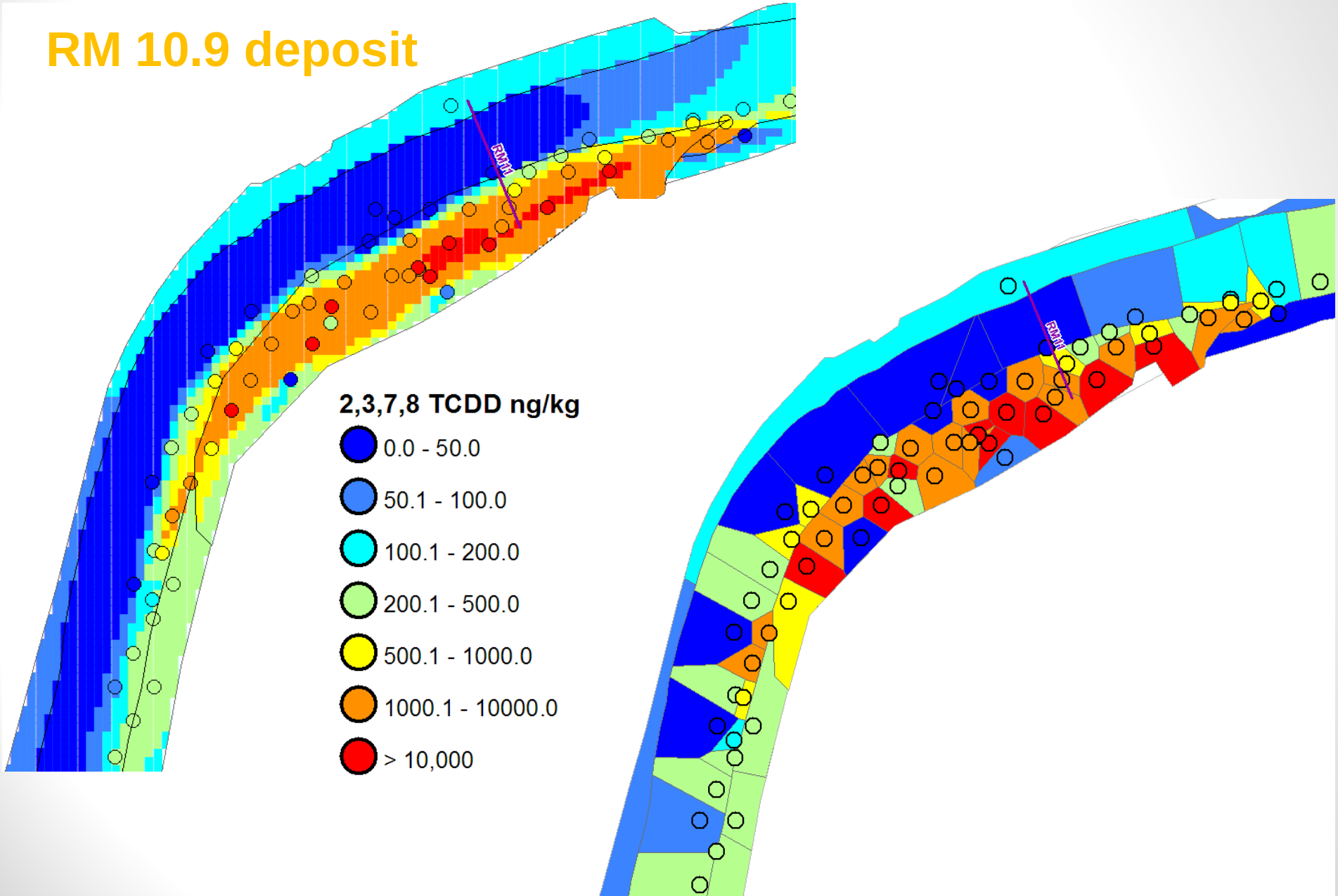
- Problematic at locations remote from measurements
  - Uses neighboring measurements that are much further away than spatial correlation distance
  - Offers no advantage over Thiessens in this respect
- Team contemplated forcing average concentration in areas without measurements by inserting synthetic data
  - Rejected this because it is without precedent
- Pursued Kriging interpolation instead
  - Kriging also smooths but uses variogram directly

Mapping Alternative #3
Kriging Approach

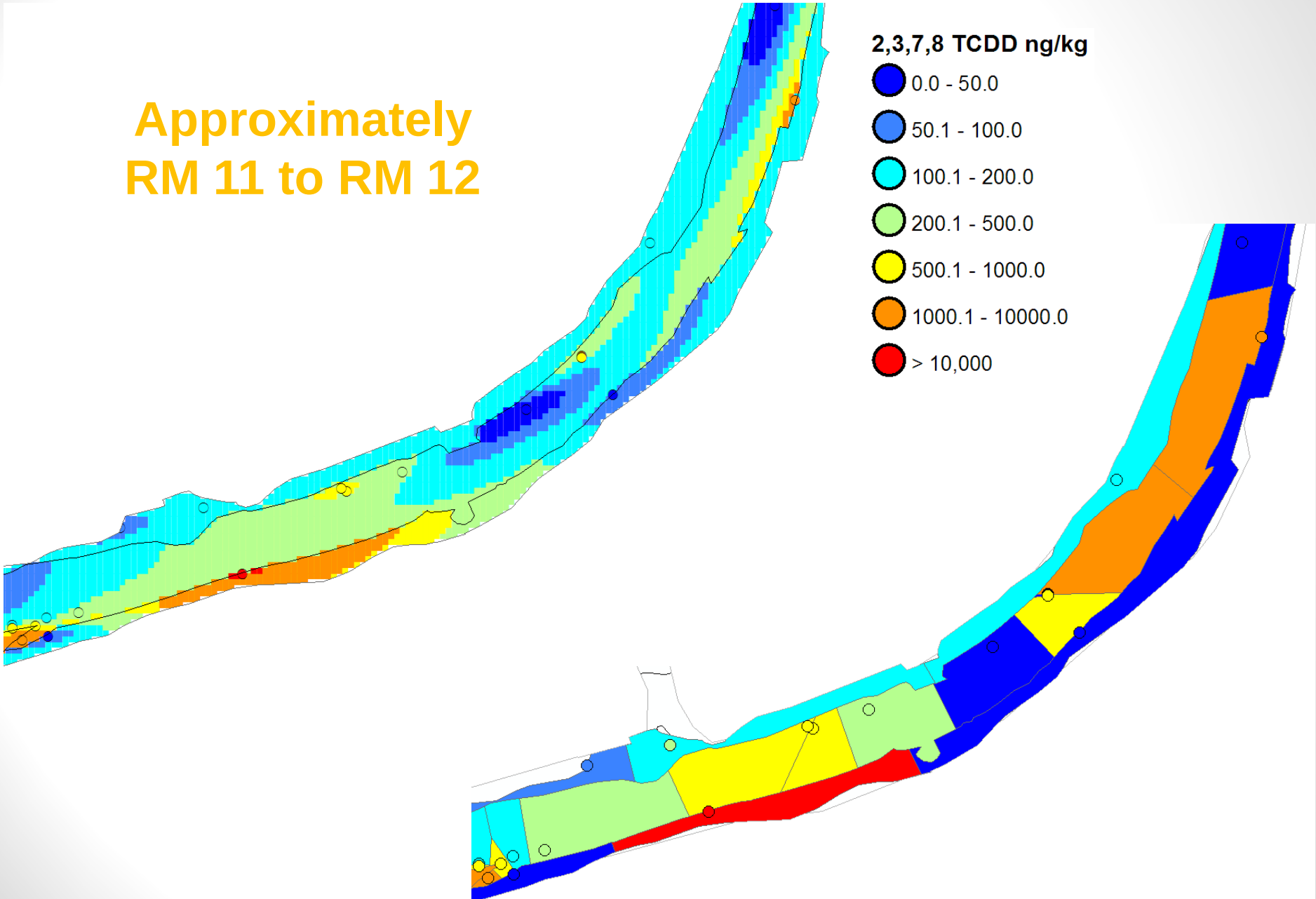
- Divide groups into longitudinal bins to yield roughly constant means
- Perform ordinary point kriging separately for each group RM bin
  - Interpolate in log-space using straightened river
  - Applying RM10.9 or straightened river variogram
  - Back-transform median (exponentiation)
- Show predicted values in original cartesian coordinates, overlaying the interpolations across all groups/bins

Comparison of Kriging to Thiessen Results

RM 10.9 deposit



Comparison of Kriging to Thiessen Results



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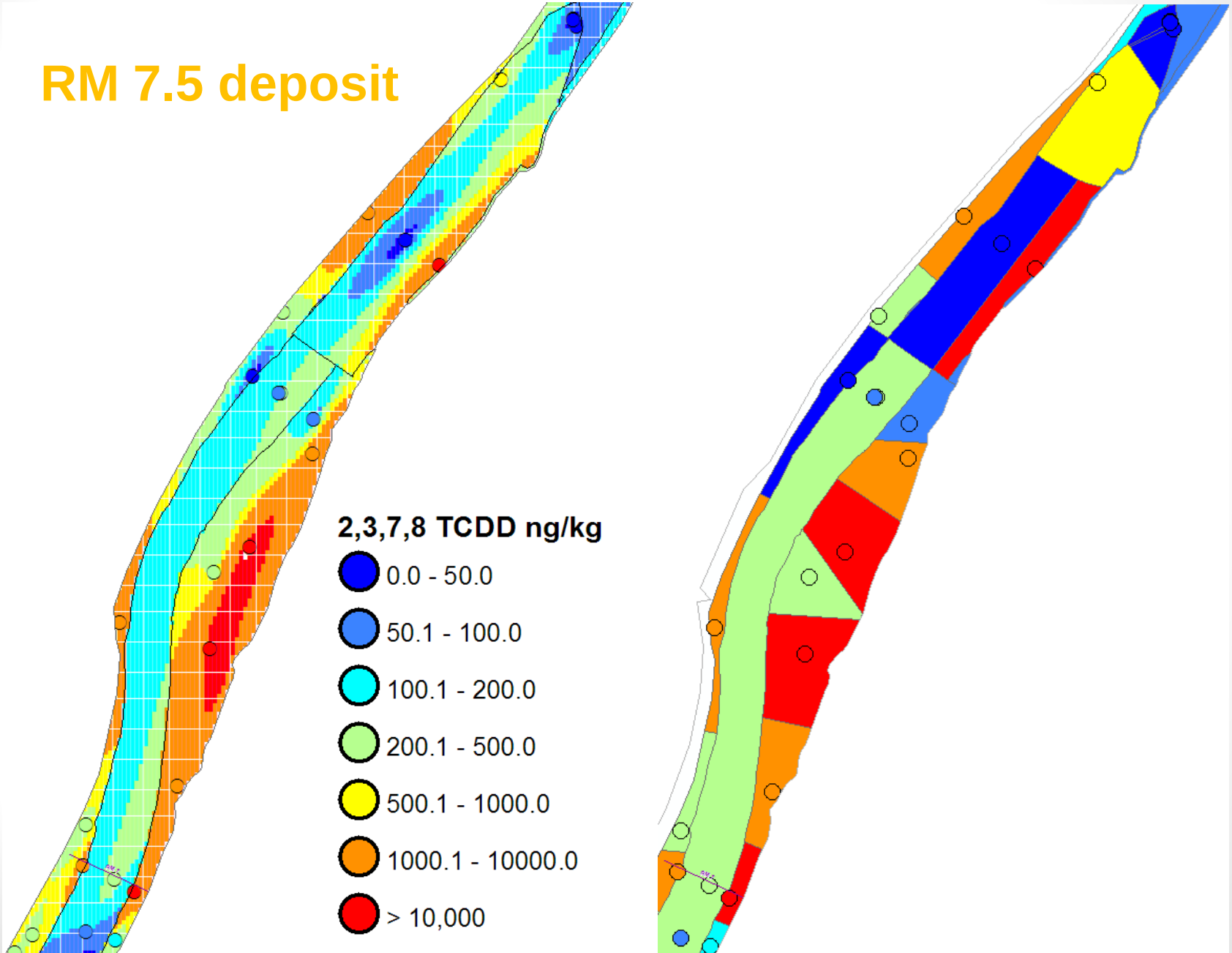
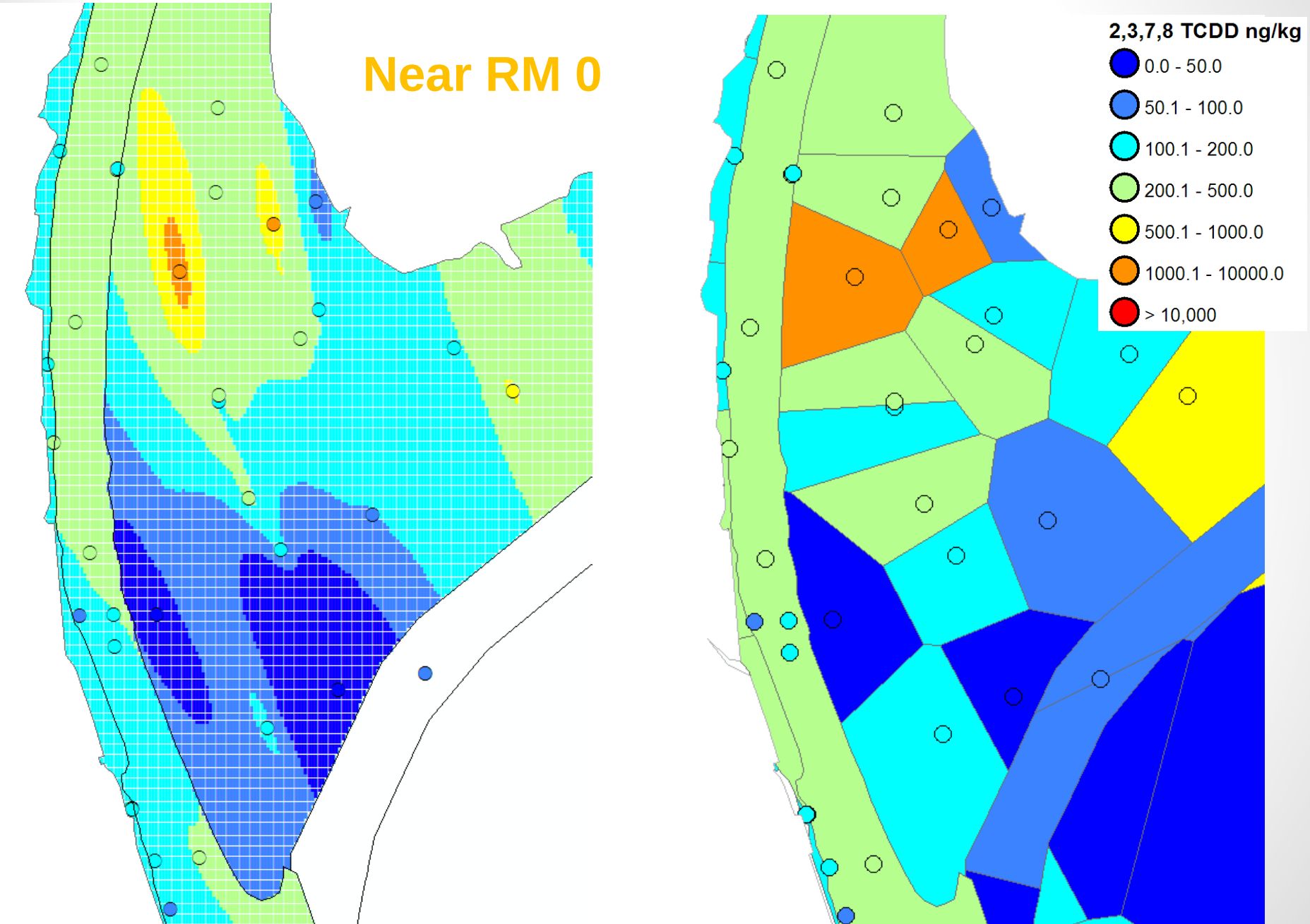


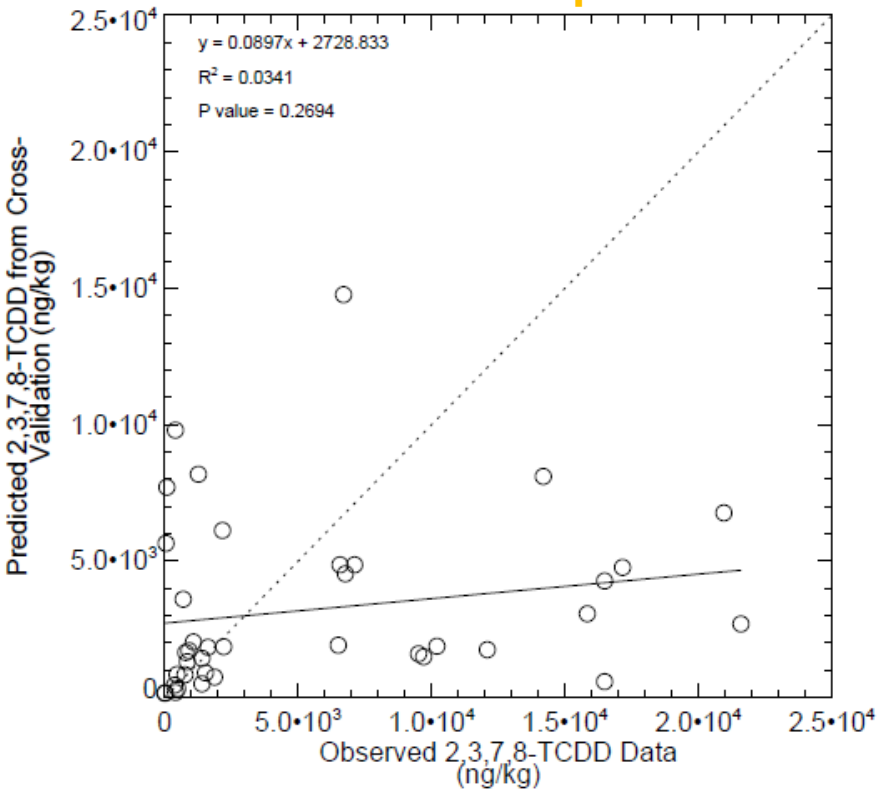
Comparison of Kriging to Thiessen Results



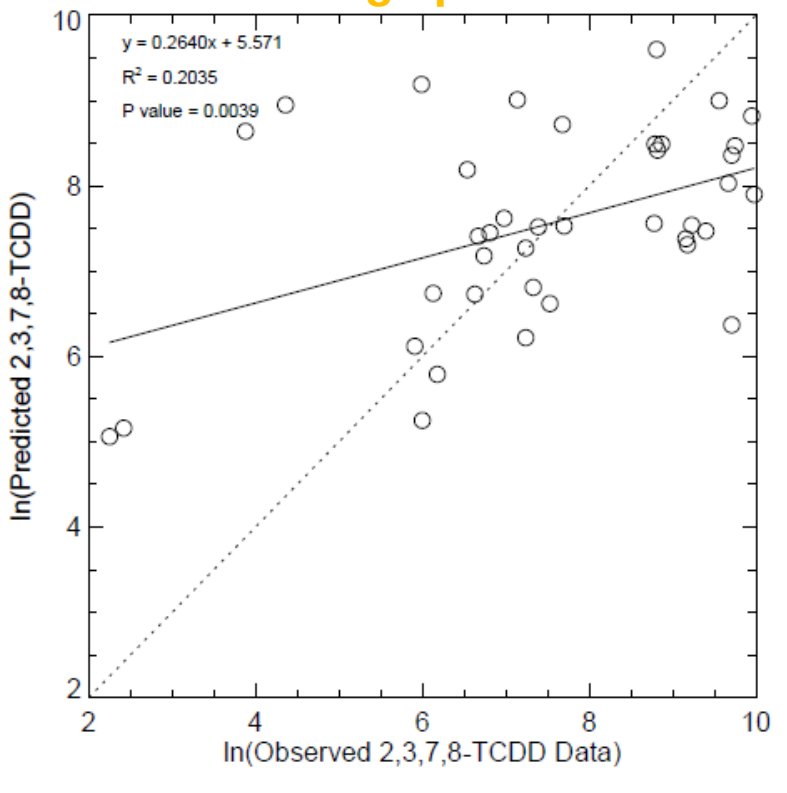
Concerns with Kriging Approach

- Unrealistic smoothing of the surface
- Uncertainty of best approach to transform results from log-space
- Poor cross-validation results (e.g., RM 10.9 bin below)

Normal space

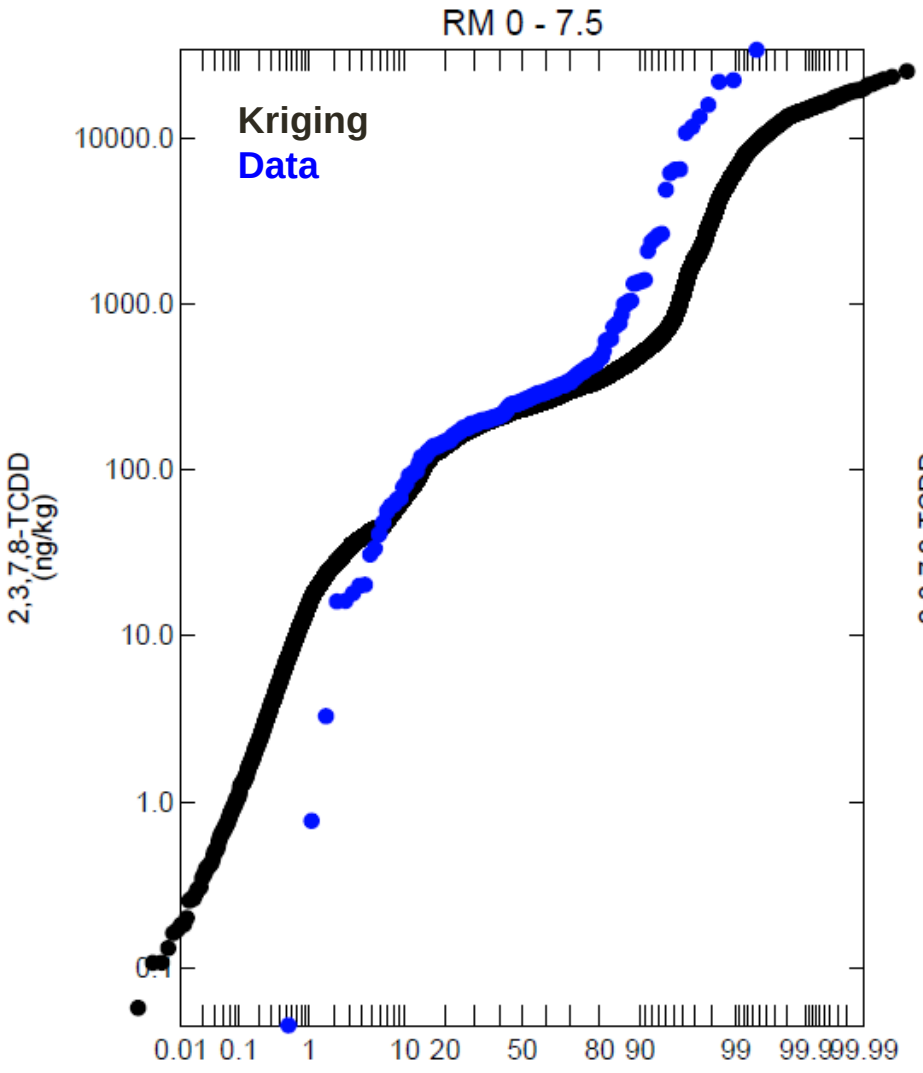


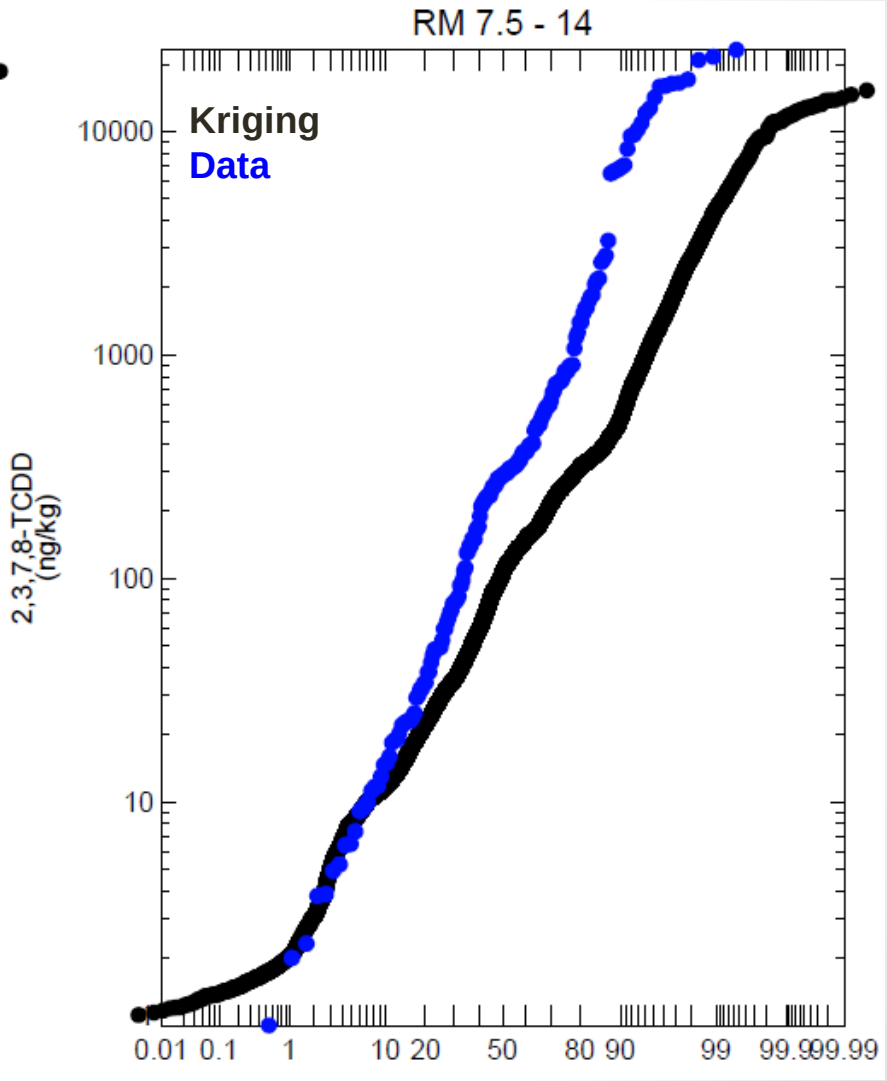
Log space



Comparison of Distributions

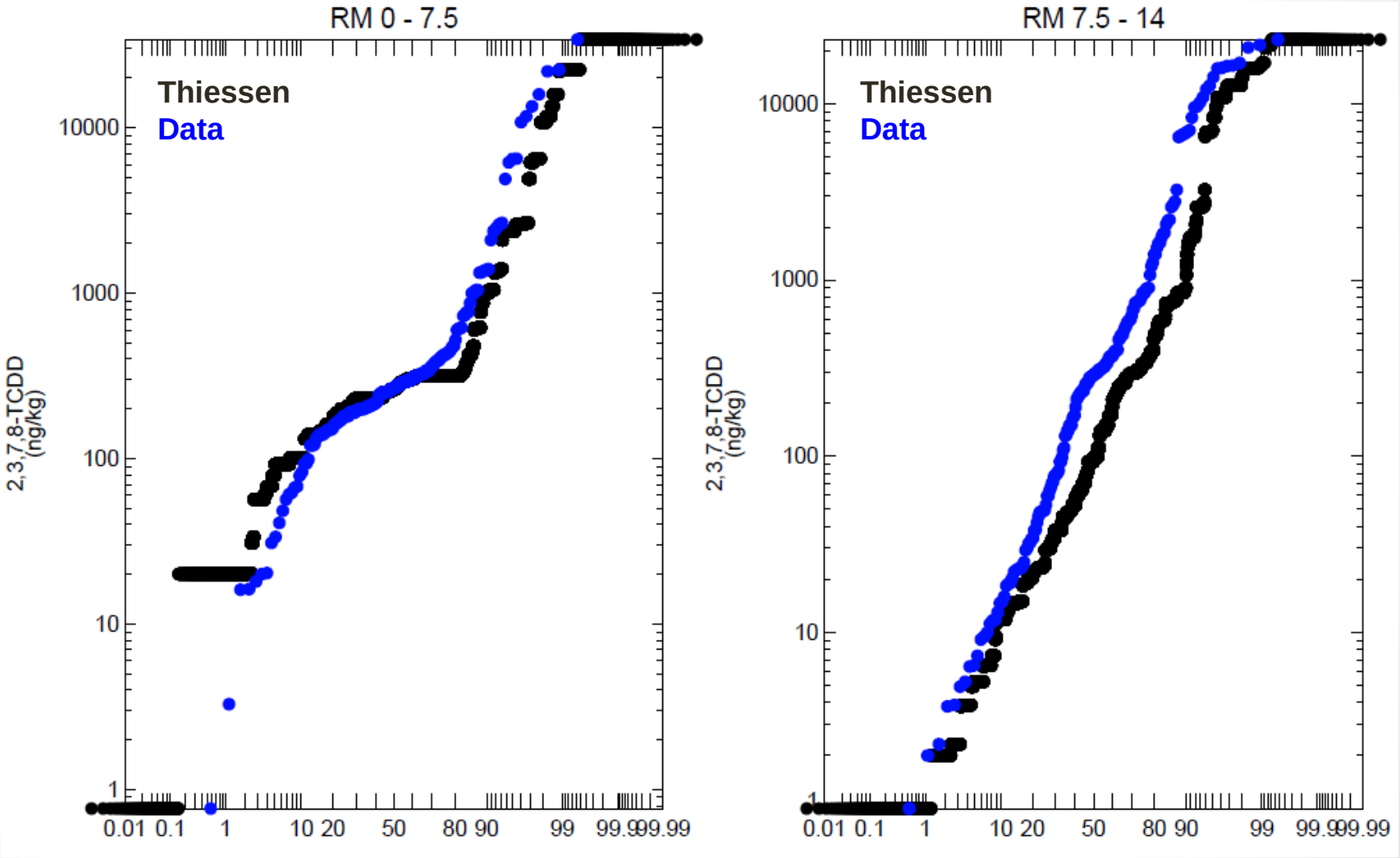
Data vs Kriging Interpolation





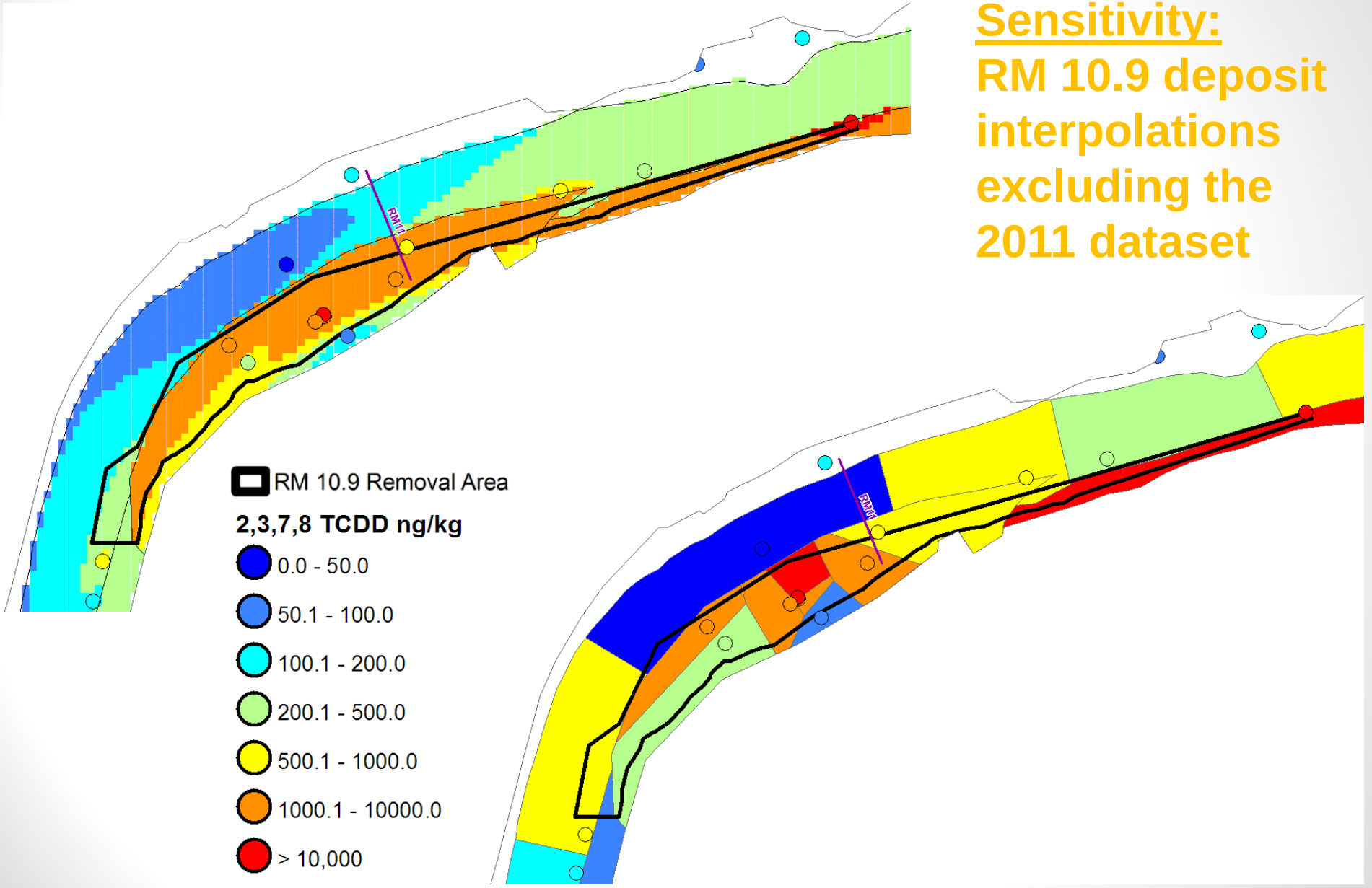
Comparison of Distributions

Data vs Thiessen Interpolation



Note: Data without corresponding thiessens occur in groups 2 and 4 due to the use of averages for these groups

Comparison of Kriging to Thiessen Results



Sensitivity:

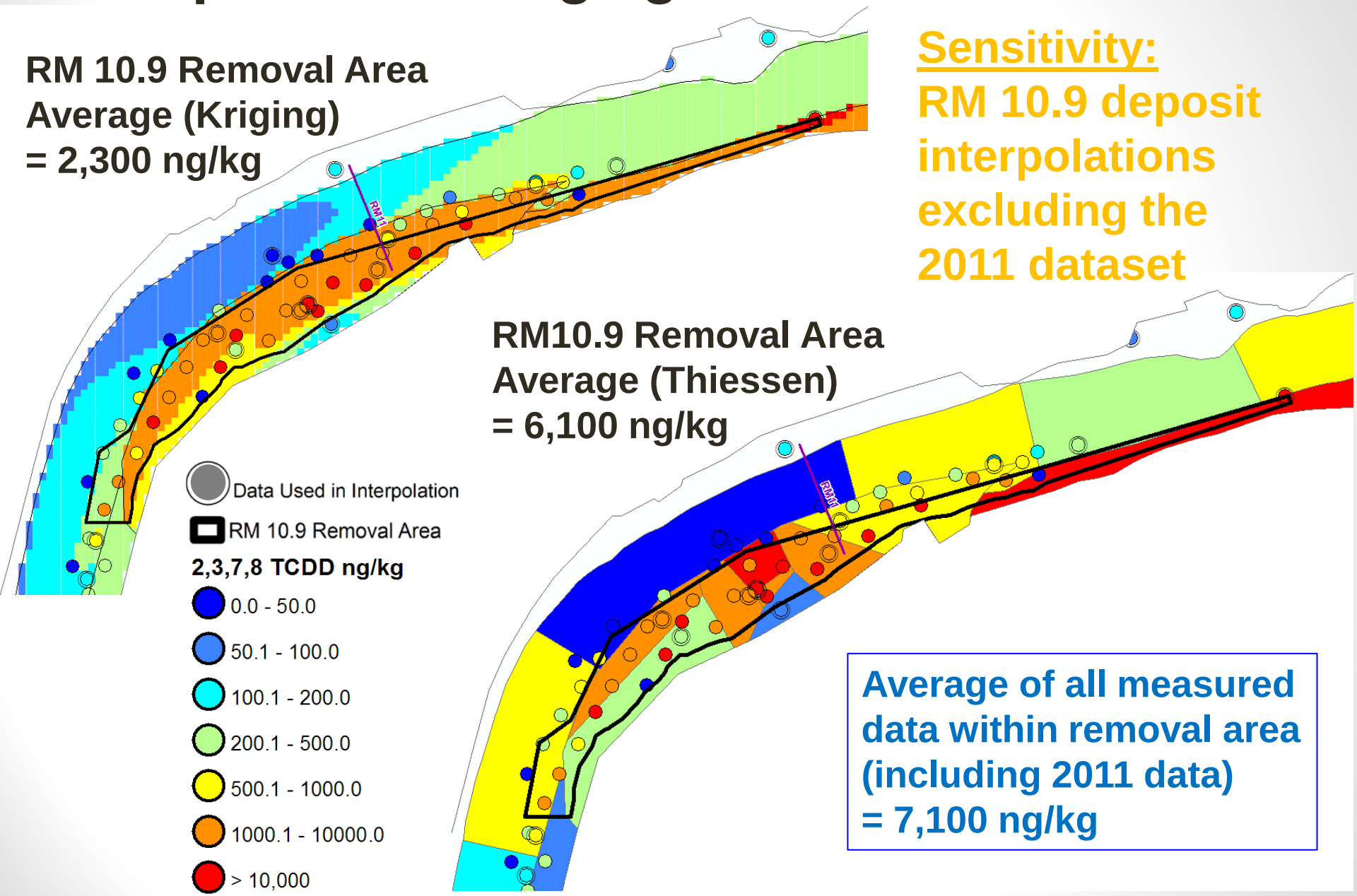
RM 10.9 deposit interpolations excluding the 2011 dataset

Comparison of Kriging to Thiessen Results

RM 10.9 Removal Area Average (Kriging) = 2,300 ng/kg

Sensitivity:
RM 10.9 deposit interpolations excluding the 2011 dataset

RM10.9 Removal Area Average (Thiessen) = 6,100 ng/kg



Average of all measured data within removal area (including 2011 data) = 7,100 ng/kg

Conclusions

- Thiessen polygons are favored because this approach performs better in honoring the data distribution
- Suggest using professional judgment to adjust extrapolation distances in areas with sparse data
- Suggest several updates as detailed on following charts

Potential Revisions to Thiessen Approach

- Append “2010” dataset to include 2005 Newark Bay data, which adds some cores to the LPR near RM 0
- Adjust sample coordinates used
  - Apply core centroids for CPG sediment datasets (LRC, FSP2, and SSP), to aid in mapping below surface and for mapping additional COPCs
- Use professional judgment to revisit group assignments for samples near group boundaries
  - Account for uncertainty in sample locations and group boundary delineations
  - Several cores identified for potential reassignment

Potential Revisions to Thiessen Approach

- Use professional judgment to limit Thiessen polygon for samples when appropriate
  - For example, one sample with a high % fines sits in a SSS coarse sediment area, and is the result of multiple sampling attempts
- Incorporate revisions to side scan sonar silt area delineations based on probing and grain size data
- Use Thiessen polygons for all groups
  - Instead of averages for groups 2 and 4

Additional Considerations

- Additional sediment data collected as part of SSP 2 will provide further information to support:
  - Conceptual Site Model development
  - COPC mapping for CFT Modeling
  - Identification of Target Areas as part of the LPRSA RI/FS
- As further data and information (e.g., SSP 2, RM 10.9) are collected and incorporated as part of an iterative and adaptive process; confidence in further refining target areas and their impact on recovery in the River will increase.